AMRL-TR-65-82

THE EFFECT OF INJECTED MONOMETHYLHYDRAZINE ON PRIMATE PERFORMANCE

HERBERT H. REYNOLDS, MAJOR, USAF
HENRY W. BRUNSON, AIRMAN FIRST CLASS, USAF

AEROMEDICAL RESEARCH LABORATORY
HOLLOMAN AIR FORCE BASE, NEW MEXICO

KENNETH C. BACK, PhD

AEROSPACE MEDICAL RESEARCH LABORATORIES
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

SEPTEMBER 1965

AEROSPACE MEDICAL RESEARCH LABORATORIES
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Notices

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Requests for copies of this report should be directed to either of the addressees listed below, as applicable:

Federal Government agencies and their contractors registered with Defense Documentation Center (DDC):

DDC
Cameron Station
Alexandria, Virginia 22314

Non-DDC users (stock quantities are available for sale from):

Chief, Input Section
Clearinghouse for Federal Scientific & Technical Information (CFSTI)
Sills Building
5285 Port Royal Road
Springfield, Virginia 22151

Change of Address.

Organizations and individuals receiving reports via the Aerospace Medical Research Laboratories' automatic mailing lists should submit the addressograph plate stamp on the report envelope or refer to the code number when corresponding about change of address or cancellation.

Do not return this copy. Retain or destroy.

The experiments reported herein were conducted according to the "Principles of Laboratory Animal Care" established by the National Society for Medical Research.

700 - January 1966 - 773 - 27-534

THE EFFECT OF INJECTED MONOMETHYLHYDRAZINE ON PRIMATE PERFORMANCE

HERBERT H. REYNOLDS, MAJOR, USAF

HENRY W. BRUNSON, AIRMAN FIRST CLASS, USAF

KENNETH C. BACK, PhD

Foreword

This experimentation, which began on 26 October 1964 and was completed on 29 October 1964, was performed jointly by members of the Aeromedical Research Laboratory, Holloman Air Force Base, New Mexico, and the Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio. The research was conducted in support of Project 6302, "Toxic Hazards of Propellants and Materials," Task 630202, "Pharmacology-Biochemistry," for the Toxic Hazards Branch, Physiology Division, Biomedical Laboratory, Aerospace Medical Research Laboratories.

This technical report has been reviewed and approved.

C. H. KRATOCHVIL, Lt Col, USAF, MC
Commander
Aeromedical Research Laboratory

WAYNE H. McCANDLESS
Technical Director
Biomedical Laboratory
Aerospace Medical Research Laboratories

Abstract

Nine macaque monkeys were injected on two occasions with either 2.5 or 5.0 mg/kg of monomethylhydrazine (MMH). Operant task performance was measured, and clinical symptoms were noted. No difference in performance resulted from the two dosage levels, but there was a greater incidence of clinical symptoms in those subjects exposed to 5.0 mg/kg. In over half the cases a performance decrement preceded clinical symptoms, but in no instance did clinical symptoms precede a performance decrement. In 3/18 cases clinical symptoms did appear without a performance decrement, but in 4/18 cases a performance decrement occurred in the absence of clinical symptoms. When initial 2.5 or 5.0 mg/kg injections are made one might predict that performance decrements will occur between 1 and 2 hours and clinical symptoms between 2 and 2.5 hours in about half the subjects. A second exposure might be expected to produce performance decrements between 1 and 2 hours and clinical symptoms between 2 and 3 hours in the majority of subjects. If a subject is influenced by MMH, clinical symptoms will likely disappear between 3 and 9 hours following injection, and performance should return to baseline level between 3 and 30 hours.

Table of Contents

Section		*Page*
I.	INTRODUCTION	1
II.	METHOD	2
	Subjects	2
	Apparatus	2
	Performance Schedule	3
	Procedure	3
III.	RESULTS	4
	Objective Data	4
	Observational Data	14
	Summary Data	17
IV.	DISCUSSION AND CONCLUSIONS	18
	REFERENCES	19

List of Illustrations

Figure		*Page*
1	Performance Chambers and Master Programming Console	2
2	Baseline and Experimental Performance, Subject No. 2	5
3	Baseline and Experimental Performance, Subject No. 9	6
4	Baseline and Experimental Performance, Subject No. 58	7
5	Baseline and Experimental Performance, Subject No. 60	8
6	Baseline and Experimental Performance, Subject No. 7	9
7	Baseline and Experimental Performance, Subject No. 8	10
8	Baseline and Experimental Performance, Subject No. 22	11
9	Baseline and Experimental Performance, Subject No. 25	12
10	Baseline and Experimental Performance, Subject No. 59	13

List of Tables

Table		*Page*
I.	Summary of Statistically Significant Decrements	4
II.	Onset and Cessation of Clinical Symptoms Following Injection (in hours)	16
III.	Relationship Between Performance Decrements and Clinical Symptoms	17

SECTION I.

Introduction

Over the years considerable experimental data have been gathered and published concerning the hydrazines. Most of the experiments have dealt with the toxicology-pharmacology and associated physiology-biochemistry-pathology of 1, 1-dimethylhydrazine (UDMH), 1, 2-dimethylhydrazine (SDMH), monomethylhydrazine (MMH) and hydrazine per se. As early as 1956 Witkin (ref 1) studied the acute toxicity of hydrazine, UDMH, SDMH, and MMH. He demonstrated that when the intravenous, intraperitoneal, and oral routes of administration were compared there was no difference in the toxicity in any of the compounds. Witkin and Weatherby had previously studied the pharmacological effects of MMH (ref 2), Back and Thomas provided the toxicological-pharmacological information on UDMH (ref 3), and Krop (ref 4) published on the toxicity of hydrazine, citing the pharmacological investigations of Thienes and Roth.

It was not until 1961 that the central nervous system effects of the hydrazines were subjected to study. In that year, and throughout 1962, Reynolds and Back (ref 5) investigated the overt behavioral changes resulting from injections of UDMH. Macaca irus were used as subjects, and further research on UDMH followed in 1963 (ref 6), suggesting that 30 mg/kg of UDMH administered intraperitoneally has a significant effect on performance, especially as the tasks become more complex and as they are presented in quick succession. It was further demonstrated that performance decrements occurred from 1.5 to 2 hours following injection, but that complete recovery to a baseline performance level might be expected by the ninth hour.

Since the earlier study of UDMH via performance media had proven of value, as well as the later study of decaborane (ref 7), it was decided that MMH should be subjected to similar study at minimal dosage levels. Thus, the purpose of this investigation was to evaluate the effects of low levels of MMH on primate performance.

SECTION II.

Method

Subjects

The subjects were nine macaque monkeys weighing between 3.1 and 6.8 kg. All monkeys had been trained on the performance tasks to various levels of proficiency over a period of several months. The reason for lacking complete asymptotic behavior in each instance was due to Mogenson (ref 8) and Singh's (ref 9) findings that more highly trained responses are less susceptible

Figure 1. Performance Chambers and Master Programming Console

to the deleterious effects of depressant agents and that there is increasing susceptibility at lower habit strength levels. It thus appeared wise to train the subjects to differential levels to more accurately evaluate the effect of MMH.

Apparatus

The apparatus was composed of two major groups of items: individual performance chambers, especially designed for psycho-pharmacological research, and a master electronic console for programming the tasks for the individual chambers (fig. 1). The inside dimensions of the work area

of each chamber were 24 by 24 by 26 inches, and the performance panel measured 13.5 by 14 inches. The performance panel included two red stimulus lights and two response levers, one set mounted on each side and slightly below a stimulus response key (SRK) from which a low intensity visual stimulus was presented.

Performance Schedule

The schedule was of 15 minutes duration and was comprised of two integrated tasks. At the onset of the red stimulus lights above the left and right levers, the subject had to press each lever at least once every 15 seconds for the full 15 minutes. If the monkey failed to respond as often as required, it received a 3-8 milliamp shock at 300-650 VAC to the soles of its feet. Since the subject diligently presses the lever to insure against shock, this task has been labeled continuous avoidance (CA) as distinguished from the Sidman avoidance schedule in which a shock-shock interval is employed. The requirement that the subject continually press both levers has further altered the Sidman schedule; thus the designation Dual CA has been given to the task just described. Throughout the 15-minute work period the visual stimulus from the SRK was presented at 0.50, 1.25, 3.00, 4.50, 5.25, 5.50, 7.5, 9.00, 10.00, 12.00, 12.75, and 14.00 minutes. The subject was required to turn off the stimulus by pressing the response key within 2 seconds (visual reaction time – VRT). Failure to respond within the alloted time resulted in a shock with the same parameters as for Dual CA.

Procedure

Subjects were rank-ordered on the performance tasks. The sum of the ranks was then calculated and two groups were formed on the basis of the sum of the ranks. After being restrained in squeeze cages, the subjects were injected ip with either 2.5 or 5.0 mg MMH per kg of body weight. The MMH was prepared in distilled water at 50 mg per cc or 0.57 cc MMH diluted to a total volume of 10 cc with distilled water. The dosages of MMH were selected on the basis of Back's previous toxicological-physiological research which indicated that these were below the lethal dosage level but probably high enough to elicit changes in overt behavior.

All subjects were injected between 0845 and 0910, and the first 15-minute performance program began at 0930. The program was presented on the half hour, i.e., 1030, 1130, etc., thereafter for a total of eight programs for each day throughout the experiment. A new solution of MMH was prepared for the second exposure and injections were accomplished between 0745 and 0800, 48 hours following the initial exposure. The performance program was then presented beginning at 0830.

SECTION III.

Results

Objective Data

The performance data are presented graphically for each subject in Figures 2-10, along with the upper and lower baseline limits. Statistically significant decrements in performance are reported in Table I. A comparison of the significant performance decrements experienced by the two groups was accomplished by the Wilcoxon matched-pairs signed-ranks test (ref 10), using the

TABLE I.

Summary of Statistically Significant Decrements*
$p^* < .01$ (one-tailed test)

Subject No.	Continuous Avoidance (CA) Left Lever *Exposure*		Continuous Avoidance (CA) Right Lever *Exposure*		Ratio of Left Lever (CA) to Right Lever (CA) *Exposure*		Visual Reaction Time *Exposure*	
	1	2	1	2	1	2	1	2
				Group I (2.5 mg/kg of MMH)				
2	X	X	X			X		X
9	X			X	X	X		X
58				X		X		
60								
Sub-Total	2	1	1	2	1	3	0	2
				Group II (5.0 mg/kg of MMH)				
7	X	X	X			X		
8								X
22	X	X	X	X				X
25								
59				X			X	X
Sub-Total	2	2	2	2	0	1	1	3
				Possible Instance of Effect and % Affected				
Group I	4(50%)	4(25%)	4(25%)	4(50%)	4(25%)	4(75%)	4(0%)	4(50%)
Group II	5(40%)	5(40%)	5(40%)	5(40%)	5(0%)	5(20%)	5(20%)	5(60%)

eight pairs of performance data resulting from: two exposures x four performance variables. The Wilcoxon test yielded a T value of 19.0, but the T had to be four or less for eight pairings to be significant at the .05 level. Thus, the null hypothesis of no difference between the two dosage levels could not be rejected.

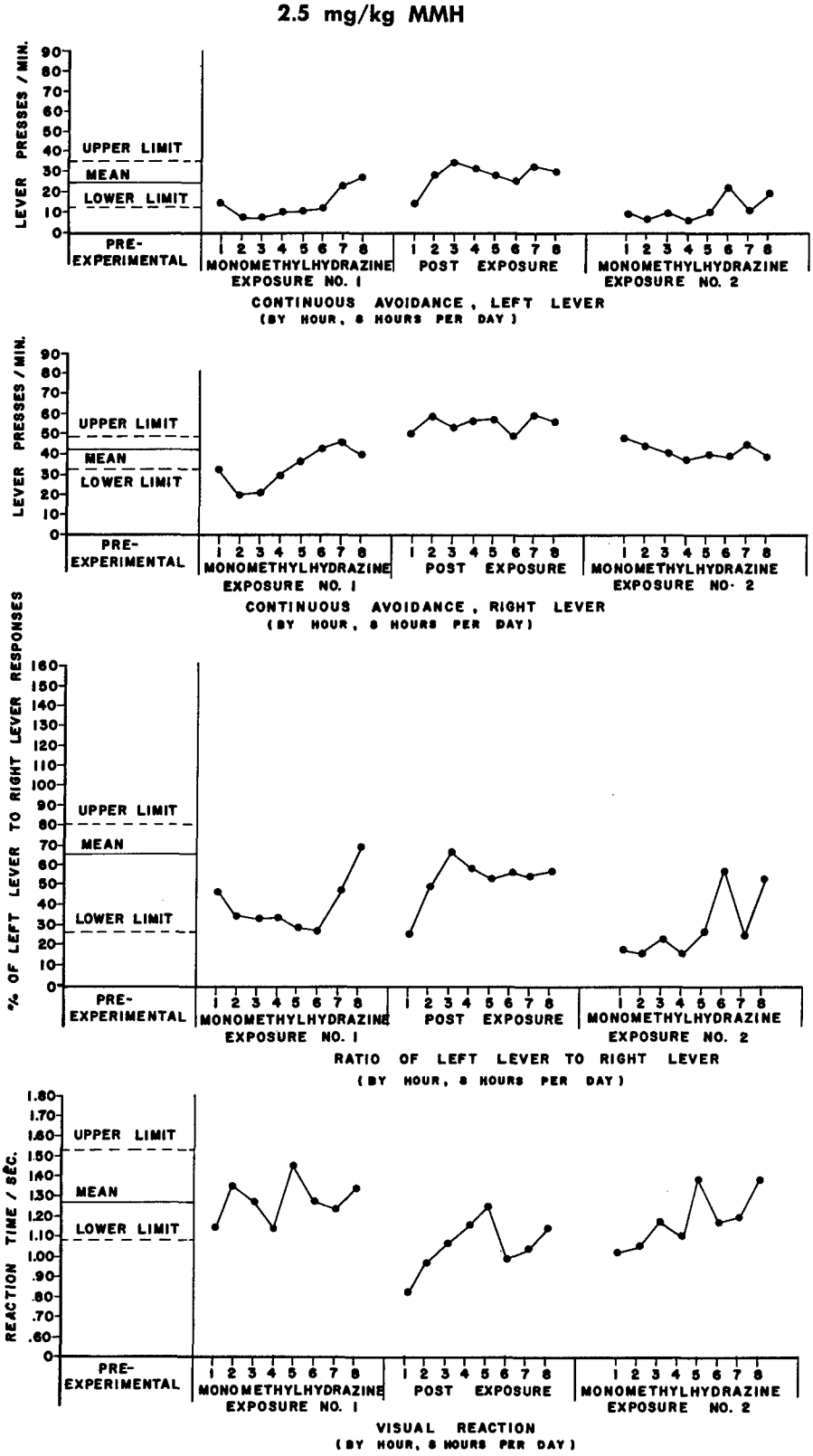

Figure 2. Baseline and Experimental Performance, Subject No. 2

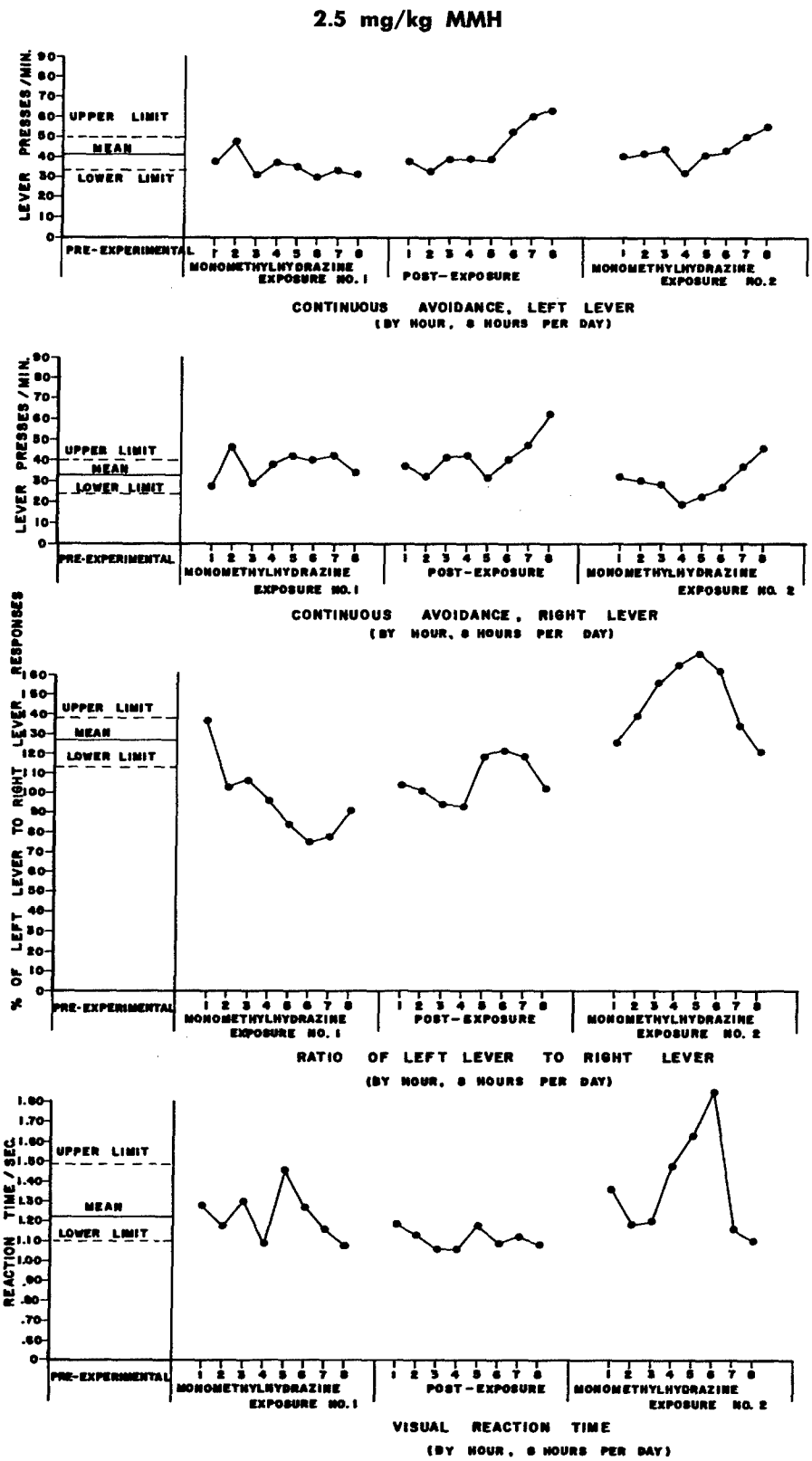

Figure 3. Baseline and Experimental Performance, Subject No. 9

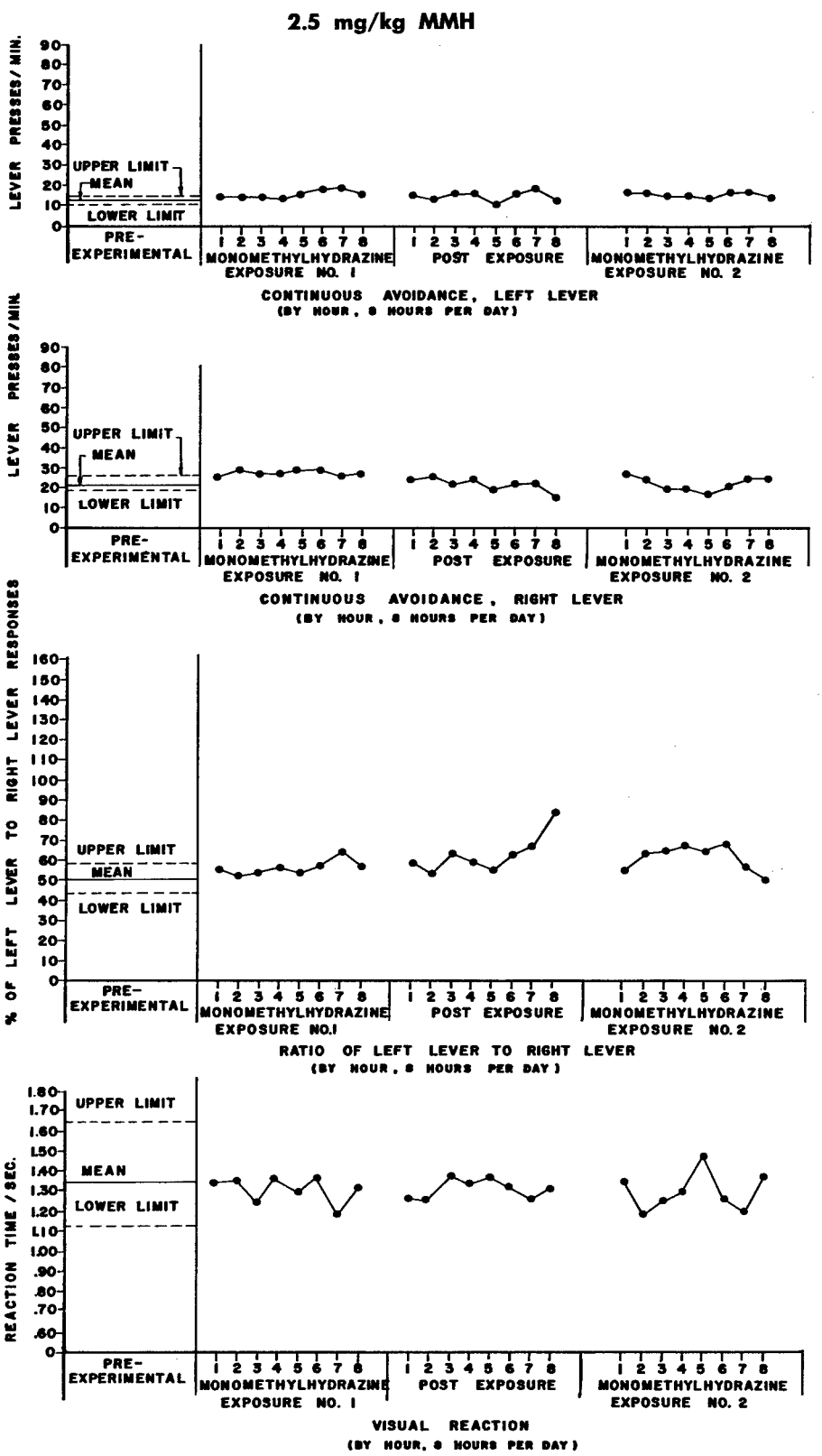

Figure 4. Baseline and Experimental Performance, Subject No. 58

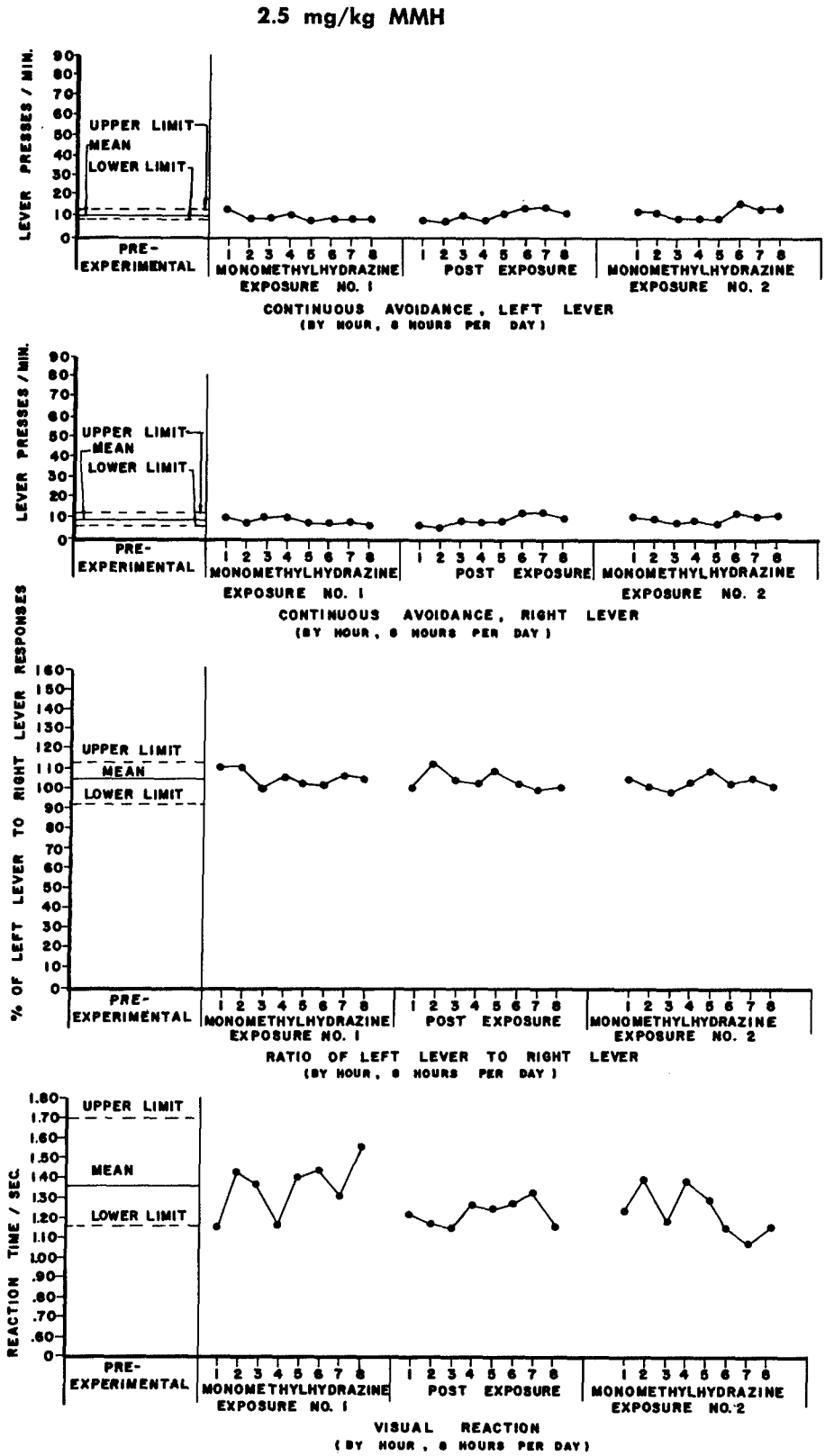

Figure 5. Baseline and Experimental Performance, Subject No. 60

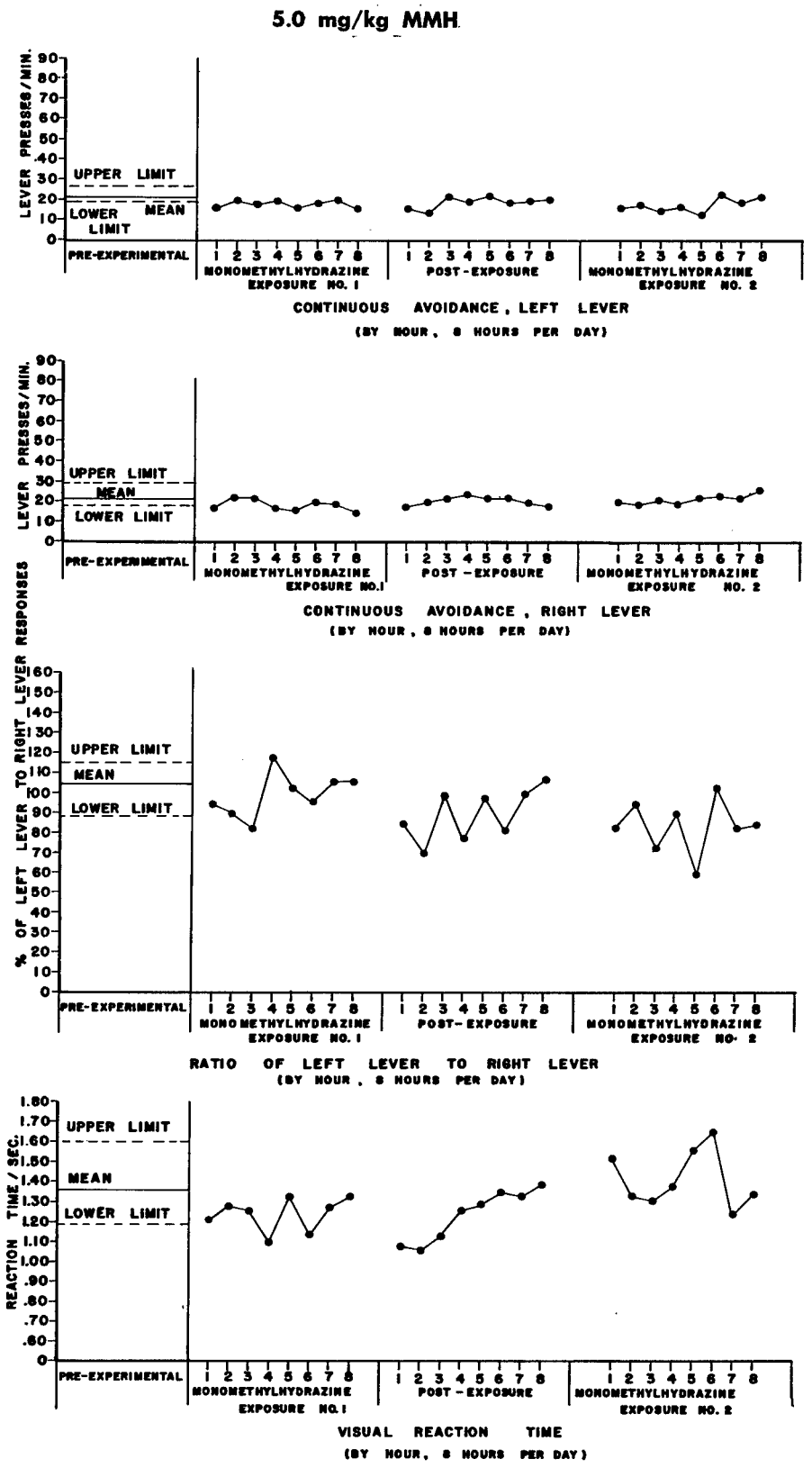

Figure 6. Baseline and Experimental Performance, Subject No. 7

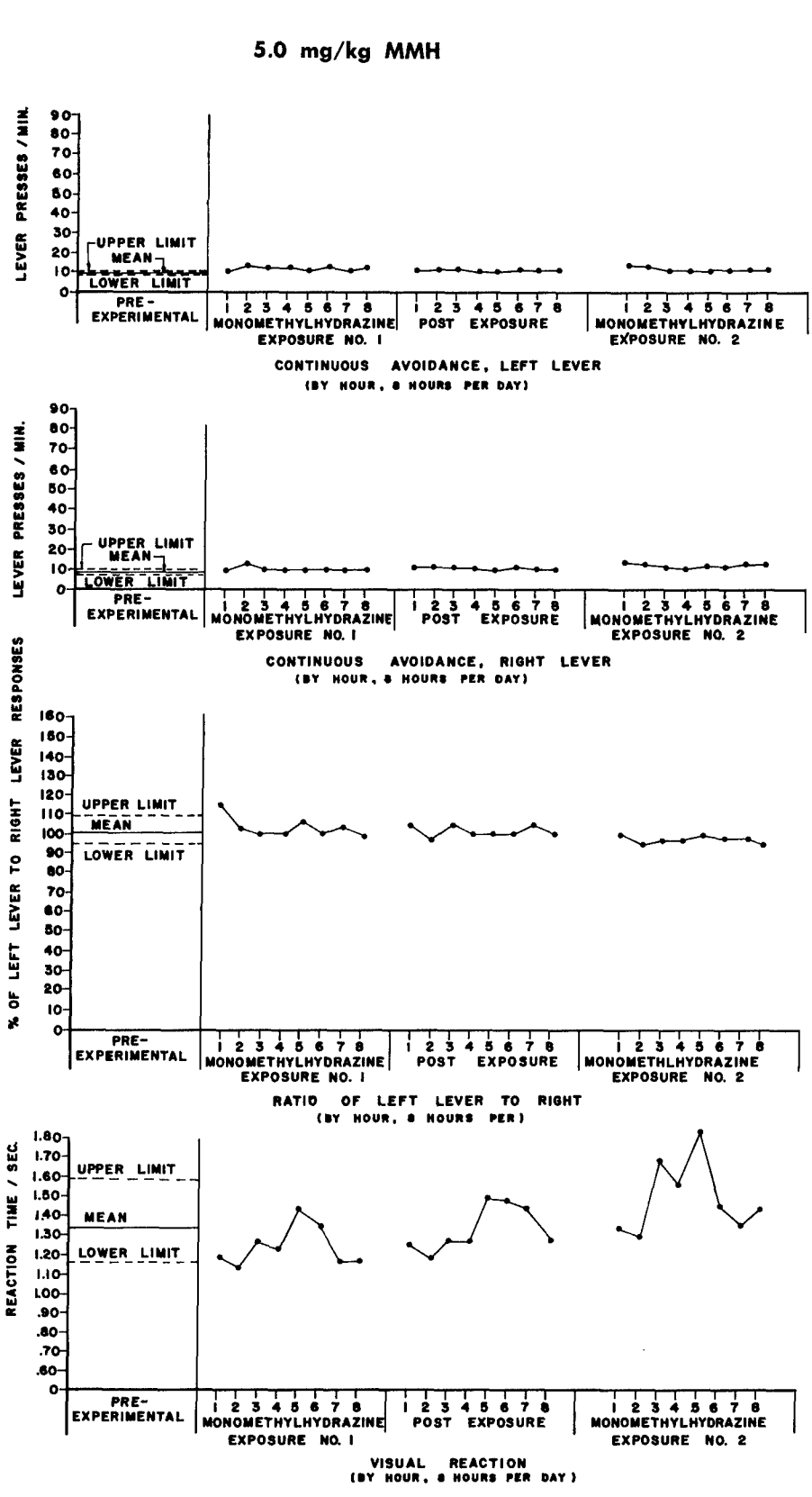

Figure 7. Baseline and Experimental Performance, Subject No. 8

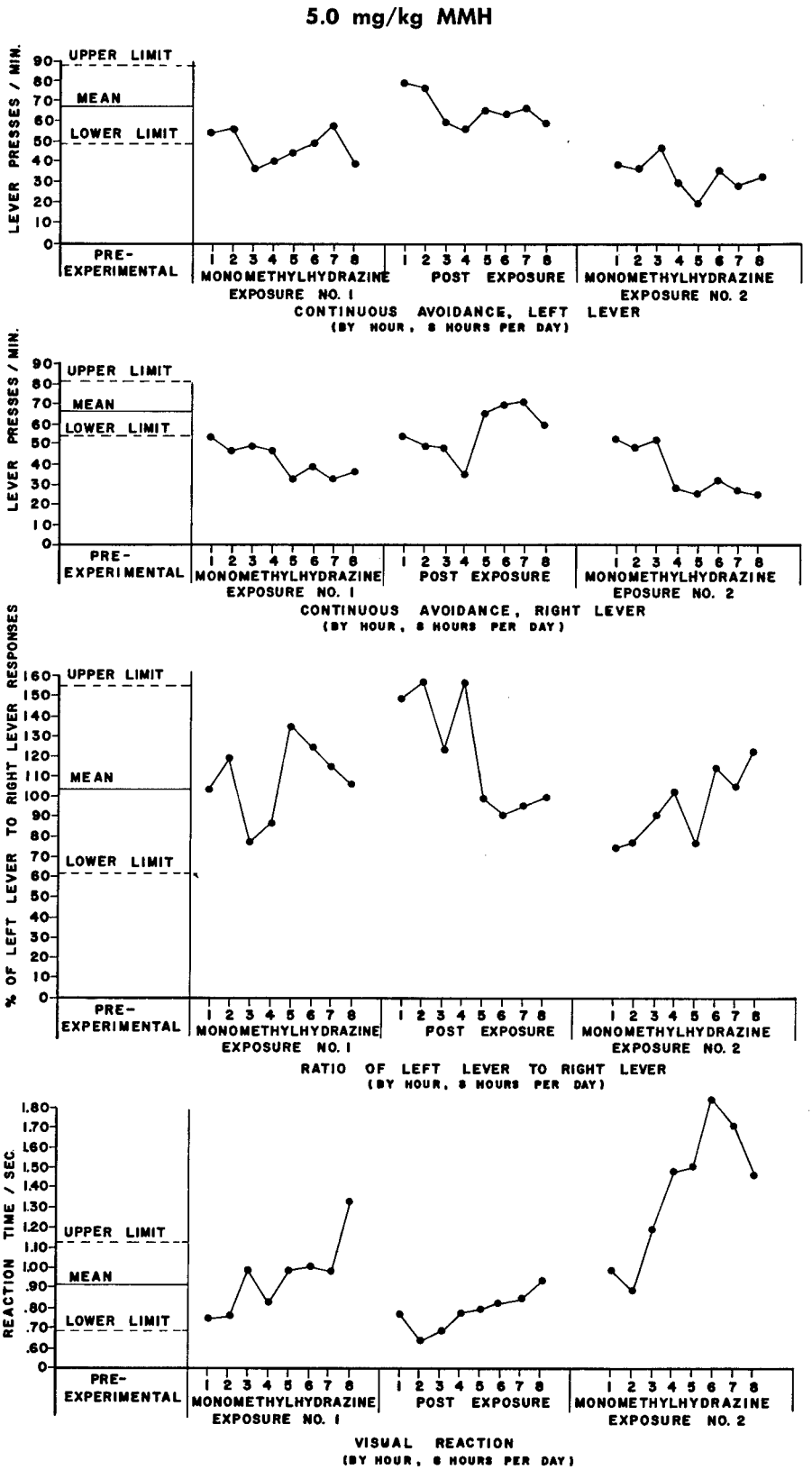

Figure 8. Baseline and Experimental Performance, Subject No. 22

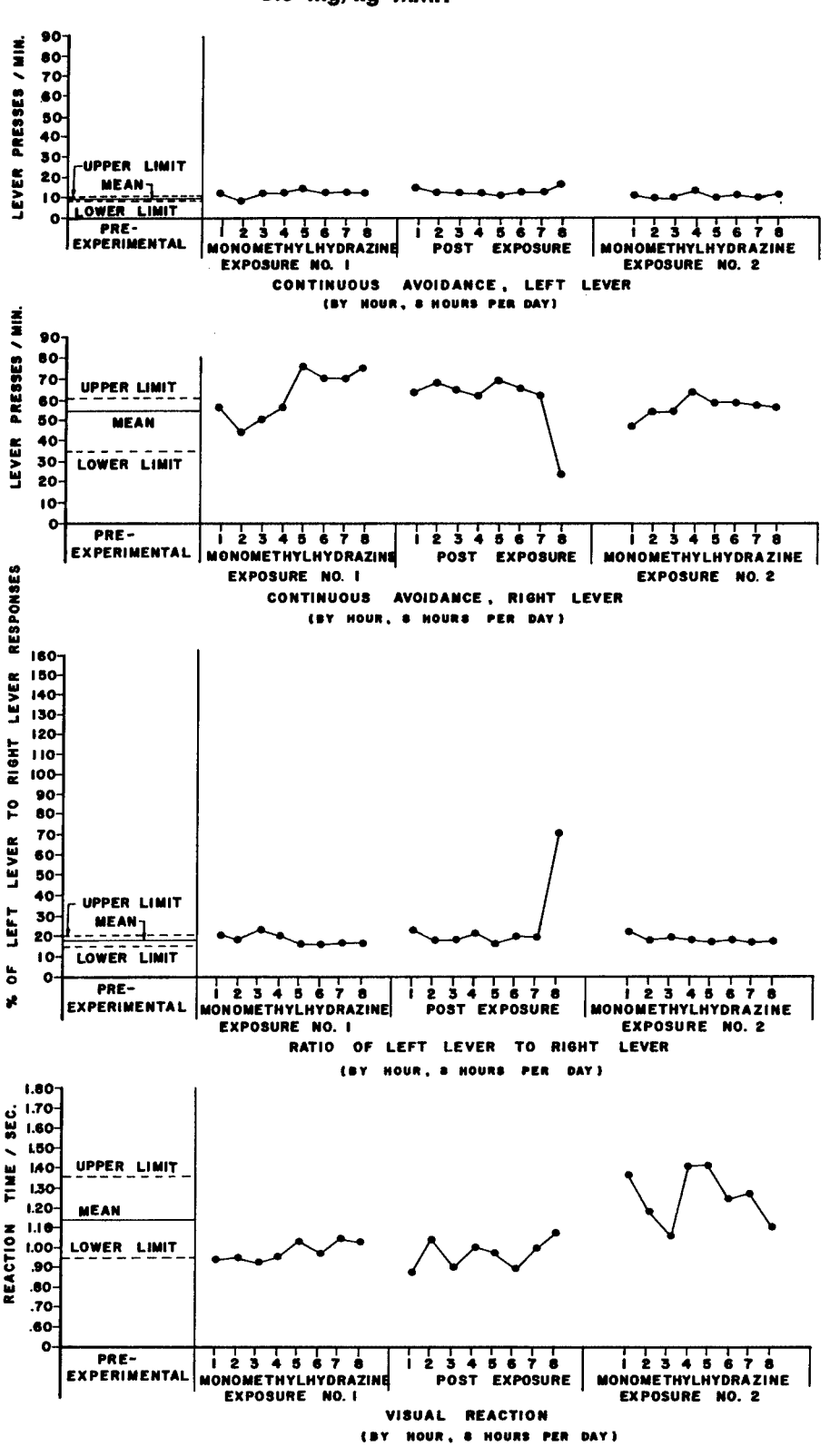

Figure 9. Baseline and Experimental Performance, Subject No. 25

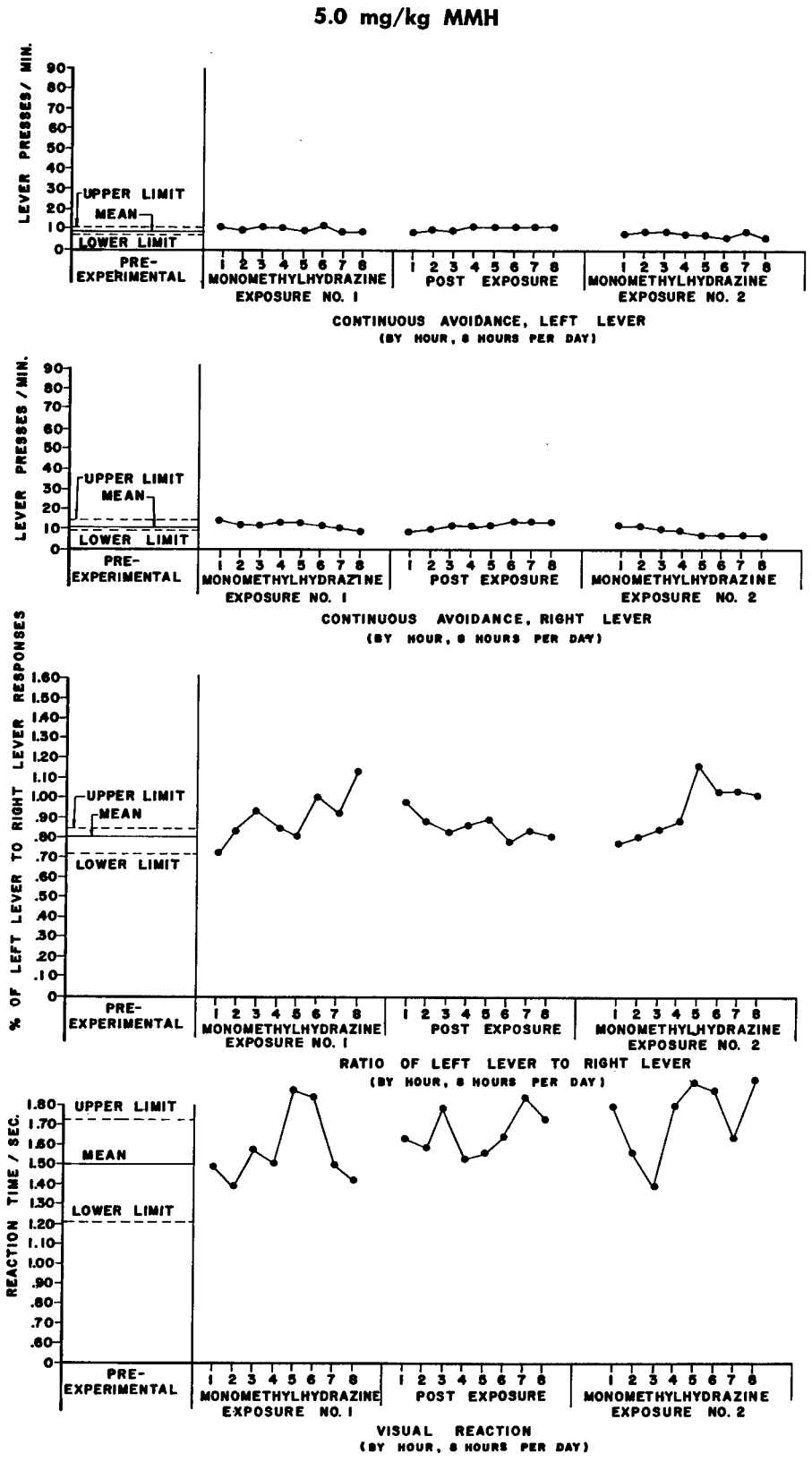

Figure 10. Baseline and Experimental Performance, Subject No. 59

Observational Data

Each subject was carefully monitored from the clinical point of view. Observations of import are reported for each of the exposures to MMH.

GROUP I (2.5 mg/kg)

Subject No. 2

Exposure No. 1 (26 Oct 64)
1056 – Emesis
1226 – Emesis (3X)
1320 – Emesis
1405 – Coughing or gagging

Exposure No. 2 (28 Oct 64)
0942 – Emesis
1007 – Emesis (3X)
1020 – Coughing
1044 – Coughing and emesis
1106 – Emesis
1105 – Emesis (3X)
1302 – Emesis

Subject No. 9

Exposure No. 1 (26 Oct 64)
No clinical symptoms

Exposure No. 2 (28 Oct 64)
No clinical symptoms

Subject No. 58

Exposure No. 1 (26 Oct 64)
No clinical symptoms

Exposure No. 2 (28 Oct 64)
No clinical symptoms

Subject No. 60

Exposure No. 1 (26 Oct 64)
No clinical symptoms

Exposure No. 2 (28 Oct 64)
0903 – Emesis
1309 – Coughing

GROUP II (5.0 mg/kg)

Subject No. 7

Exposure No. 1 (26 Oct 64)
0955 – Considerable emesis
0957 – Emesis
1050 – Emesis
1355 – Retching

Exposure No. 2 (28 Oct 64)
0826 – Gagging, coughing and chewing
0830 – Emesis, just at start of work session; however, the subject promptly went to work.
0840 – Emesis
0852 – Emesis
1012 – Emesis
1040 – Emesis
1055 – Emesis (2X)
1120 – Emesis
1150 – Emesis
1302 – Emesis
1402 – Emesis (2X)

Subject No. 8

Exposure No. 1 (26 Oct 64)
1100 – Retching

Exposure No. 2 (28 Oct 64)
1312 – Emesis (2X)
1510 – Emesis

Subject No. 22

Exposure No. 1 (26 Oct 64)
1124 – Retching
1211 – Emesis
1410 – Retching
1625 – Lying on side on chamber floor

Exposure No. 2 (28 Oct 64)
1012 – Emesis
1128 – Emesis

Subject No. 25

Exposure No. 1 (26 Oct 64)
No clinical symptoms

Exposure No. 2 (28 Oct 64)
0853 – Saliva in cage, possibly slight emesis.
0929 – Emesis
1010 – Emesis
1318 – Emesis (2X)

Subject No. 59

Exposure No. 1 (26 Oct 64)
No clinical symptoms

Exposure No. 2 (28 Oct 64)
1011 – Emesis
1028 – Emesis
1048 – Emesis

1121 – Emesis
1152 – Emesis (2X)
1300 – Emesis
1326 – Emesis
1409 – Emesis
1502 – Emesis (3X)

Table II indicates the hours that clinical symptoms were first and last observed for each subject.

TABLE II.

Onset and Cessation of Clinical Symptoms Following Injection (in hours)

Subject	Onset		Cessation	
No.	Exposure 1	Exposure 2	Exposure 1	Exposure 2
		Group I (2.5 mg/kg of MMH)		
2	2	2	5	5¼
9	N/A	N/A	N/A	N/A
58	N/A	N/A	N/A	N/A
60	N/A	1	N/A	5¼
		Group II (5.0 mg/kg of MMH)		
7	1	1	5	6¼
8	2	5¼	2	7¼
22	2½	2¼	7½	3¾
25	N/A	1½	N/A	5½
59	N/A	2½	N/A	7¼

Table II shows that clinical symptoms were observed more frequently in Group II than in Group I. In the first exposure the ratio was 3:1, and in the second exposure the ratio was 5:2.

Summary Data

Since an important question concerns the relationship between clinical symptoms and performance decrements, Table III was constructed. This table demonstrates the relationship in terms of the time of occurrence of either sickness or a decrement. Percentage values are provided to highlight the differences in sensitivity of the two variables.

TABLE III.

Relationship Between Performance Decrements and Clinical Symptoms

Subject No.	Instances of Clinical Symptoms Preceding Performance Decrements	Instances of Performance Decrement Preceding Clinical Symptoms	Occurring Simultaneously	Instances of Clinical Symptoms Without Performance Decrement	Instances of Performance Decrement Without Clinical Symptoms	Neither Performance Decrement nor Clinical Symptoms
			Group I (2.5 mg/kg)			
2		2				
9					2	
58		1			1	
60				1		1
			Group II (5.0 mg/kg)			
7		1	1			
8			1	1		
22		2				
25				1		1
59			1		1	
Summary	0(0%)	6(33.3%)	3(16.7%)	3(16.7%)	4(22.2%)	2(11.1%)

Note: 9 Ss x 2 Exposures = 18 possible Instances of Effect

SECTION IV.

Discussion and Conclusions

The results indicate that low dosages of MMH definitely have an effect on the central nervous system as evidenced by significant performance decrements at both 2.5 and 5.0 mg/kg. Wilcoxon's test provided further information to the effect that there were no differences in performance between the two dosage levels. On the other hand, there was evidence that clinical symptoms appeared more often in the subjects receiving the higher dosage.

With regard to the relationship between the onset of clinical symptoms versus performance decrements, Table III shows clearly that in over half the cases (10/18) a performance decrement preceded clinical symptoms or occurred without concomitant clinical symptoms. In no instance did clinical symptoms precede a performance decrement and in only 3/18 cases did clinical symptoms appear without a performance decrement. Thus, the value of performance measures in toxicological research is readily apparent.

In summary, when initial 2.5 or 5.0 mg/kg injections are made one might predict that performance decrements will occur between 1 and 2 hours and clinical symptoms between 2 and 2.5 hours in about half the subjects. A second exposure might be expected to produce performance decrements between 1 and 2 hours and clinical symptoms between 2 and 3 hours in the majority of subjects. If a subject is influenced by MMH, clinical symptoms will likely disappear between 3 and 9 hours following injection and performance should return to a baseline level between 3 and 30 hours.

References

1. Witkin, L. B. "Acute Toxicity of Hydrazine and Some of its Methylated Derivatives." *AMA Arch Ind Health, 13,* No. 1, pp. 34-36, 1956.
2. Witkin, L. B. and J. H. Weatherby. "Some Pharmacological Effects of Methylhydrazine." *Fed. Proc., 14,* p. 395, 1955.
3. Back, K. C. and A. A. Thomas. "Pharmacology and Toxicology of 1, 1-Dimethylhydrazine (UDMH)." *American Ind Hyg Assoc Journal, 24,* p. 23, 1963.
4. Krop, S. "Toxicity of Hydrazine." *AMA Arch Ind Hyd, 9,* p. 199, 1954.
5. Reynolds, H. H., F. H. Rohles, J. Fineg, K. C. Back, and A. A. Thomas. "The Effect of UDMH on Learned Behavior in the Java Monkey." *Aerospace Medicine, 34,* No. 10, pp. 920-922, 1963.
6. Reynolds, H. H., F. H. Rohles, J. R. Prine, and K. C. Back. "The Effect of 1, 1-Dimethylhydrazine (UDMH) on Complex Avoidance Behavior in the Java Monkey." *Aerospace Medicine, 35,* No. 4, 1964.
7. Reynolds, H. H. and K. C. Back. "The Effect of Decaborane Injection on Macaca Mulatta and Macaca Irus Operant Behavior." *J. Toxicology and Applied Pharmacology* (In Press).
8. Mogenson, G. J. "On Habit Interference from Cortical Stimulation." *Psychol. Rep., 12,* p. 830, 1963.
9. Singh, S. D. "Habit Strength and Drug Effects." *J. Comp. Physiol. Psy., 58,* pp. 468-469, 1964.
10. Siegel, S. "Nonparametric Statistics." McGraw-Hill Book Co., Inc., N. Y., 1956.

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* Aeromedical Research Laboratory, Holloman AFB, New Mexico, Aerospace Medical Research Laboratories Wright-Patterson AFB, Ohio	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b GROUP N/A

3. REPORT TITLE

THE EFFECT OF INJECTED MONOMETHYLHYDRAZINE ON PRIMATE PERFORMANCE

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Final Report, 26 October 1964 - 29 October 1964

5. AUTHOR(S) *(Last name, first name, initial)*

Herbert H. Reynolds, Major, Henry W. Brunson, Airman First Class, Kenneth C. Back, PhD.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1965	25	10

8a. CONTRACT OR GRANT NO. b. PROJECT NO 6302 c. Task No, 630202 d.	9a. ORIGINATOR'S REPORT NUMBER(S) AMRL-TR-65-82 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. AVAILABILITY/LIMITATION NOTICES

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Aerospace Medical Research Laboratories Aerospace Medical Division, Air Force Systems Command, Wright-Patterson AFB, Ohio

13. ABSTRACT

Nine macaque monkeys were injected on two occasions with either 2.5 or 5.0 mg/kg of monomethylhydrazine (MMH). Operant task performance was measured and clinical symptoms were noted. No difference in performance resulted from the two dosage levels, but there was a greater incidence of clinical symptoms in those subjects exposed to 5.0 mg/kg. In over half the cases a performance decrement preceded clinical symptoms, but in no instance did clinical symptoms precede a performance decrement. In 3/18 cases clinical symptoms did appear without a performance decrement, but in 4/18 cases a performance decrement occurred in the absence of clinical symptoms. When initial 2.5 or 5.0 mg/kg injections are made one might predict that performance decrements will occur between 1 and 2 hours and clinical symptoms between 2 and 2.5 hours in about half the subjects. A second exposure might be expected to produce performance decrements between 1 and 2 hours and clinical symptoms between 2 and 3 hours in the majority of subjects. If a subject is influenced by MMH, clinical symptoms will likely disappear between 3 and 9 hours following injection, and performance should return to baseline level between 3 and 30 hours.

DD FORM 1 JAN 64 1473

AF-WP-B-AUG 64 400

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
primates Toxicology Monomethylhydrazine Performance Pharmacology						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2*a*. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2*b*. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7*a*. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7*b*. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8*a*. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8*b*, 8*c*, & 8*d*. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9*a*. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9*b*. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through

_____."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through

_____."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through

_____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS), (S), (C), or (U)*

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.